

a new generation of researchers in the basics of quantum control.

The book is certainly timely because the field is rapidly becoming too wide to encompass the fundamentals of quantum control in a single monograph. Shapiro and Brumer's book begins with a brief but pedagogical two-chapter review of laser-matter interactions, with a particular emphasis on photodissociation. Virtually no steps are left out, so graduate students or their professors will have no trouble following the detailed derivations.

The essence of the book begins with chapters 3 through 5. Chapter 3 describes the Brumer-Shapiro route to quantum control, in which the final state specificity comes from the interference between multiple pathways in multiphoton transitions from the initial to the final states. This method emphasizes the role of phase coherence in the control mechanism. The first section of chapter 4 covers the Tannor-Rice scheme in which control is achieved with multiple ultrafast optical pulses. The first "pump" pulse promotes the molecule to a nonstationary excited state, where it evolves for a time and is then de-excited to the desired final state by a second "dump" pulse.

By putting the two schemes in separate sections of the book, Brumer and Shapiro can explain each scheme using its own natural language; that is, they describe the Brumer-Shapiro control as multimode interference between stationary states and the Tannor-Rice control as wavepacket evolution of nonstationary states. These quantum control schemes are concepts rather than prescriptions. In fact, in many respects, they are just two different views, temporal and spectral, of the same process. This commonality is explored in section 3.5.

In a typical polyatomic molecule, which has dozens or more coupled modes and is immersed in a solvent or embedded in a solid at room temperature, the specific path to control is far from clear. The field of quantum control would not have blossomed were it not for the pioneering development of feedback search strategies, one of the great stories laid out in this book. Calculations have yielded control fields even in the presence of many modes and decoherence pathways through the use of optimal control theories (for example, by Herschel Rabitz, Ronnie Kosloff, Tannor, and many others).

Experiments have yielded, through programmable pulse shaping and learning algorithms, complicated field solutions involving hundreds of different amplitude- and phase-controlled frequencies. Understandably, Shapiro and Brumer spend more pages on the theoretical challenges and calculation techniques than on the experimental methods. The second half of chapter 4 contains a tutorial on optimal control theory, which I found particularly useful and illuminating. Chapter 5 discusses the most important aspects of decoherence and loss of control.

Chapters 6 through 8 survey the field of quantum control. They contain several case studies covering calculations or experiments that demonstrate two-color control, control of chaotic dynamics, control of bimolecular processes, and control to achieve chiral selectivity. Even though it only skims the surface of the work that has been done in the field, the material in these chapters is interesting and useful. Chapter 13, "Case Studies in Optimal Control," could easily have gone in this part as well.

The last part of the book, chapters 9 through 13, goes beyond the weak-field limit to explore control problems for which lowest-order perturbation theory is inappropriate. Here, the book cannot even be a comprehensive introduction, because the range of topics and list of observed phenomena are too vast. Rather, the authors choose several topics and explore each briefly. Shapiro and Brumer's style is to stick to problems in which simple analytical techniques can give physical insight. Chapter 9 covers stimulated adiabatic population transfer problems, electromagnetically induced transparency, and lasing without inversion—problems that can all be understood using few-level coupled systems and dressed-state formalism. Chapters 10 and 11 cover some problems in photodissociation and continuum-continuum transitions. In all cases, the book is distinguished by its clear derivations.

In chapter 12, the focus moves to the strong-field regime where the laser electric-field amplitude becomes comparable to the binding fields in the molecule. Oddly, the chapter begins with the quantization of the electromagnetic field even though calculations in the strong-field regime do not require this field quantization. Nonetheless, the chapter goes on to

good discussions of some problems of current interest, most notably molecular-bond softening and molecular focusing and alignment due to light-induced potentials. But the authors do not mention standard approaches to strong-field interactions, such as Keldysh-Faisal-Reiss theory or the rescattering model, and they also do not mention above-threshold ionization or high harmonics in molecules. Those subjects have contributed to the general field of quantum control. Even basic concepts like the ponderomotive potential are not covered. Perhaps, though, it is too much to expect a single volume on quantum control to cover all of the territory. Any weakness in chapter 12 does not detract much from the main strength of the book, which is a thorough treatment of weak-field quantum control.

My overall impression of *Principles of the Quantum Control of Molecular Processes* is extremely positive. In fact, I would like to use the book as a basis for a graduate course on quantum control, and I recommend it to anyone who wishes to know more about the subject. Shapiro and Brumer have been pioneers in the field for 20 years, and the book is another impressive contribution from them.

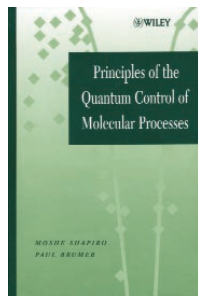
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Ink Sandwiches, Electric Worms and 37 Other Experiments for Saturday Science

Neil A. Downie
Johns Hopkins U. Press, Baltimore, MD, 2003. \$45.00, \$18.95 paper (334 pp.). ISBN 0-8018-7409-2, ISBN 0-8018-7410-6 paper

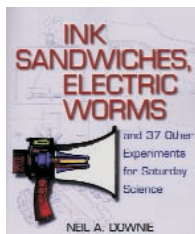
At the University of British Columbia, we run a fourth-year physics course in which students who are interested in a teaching career learn how to build physics demonstrations and present them in schools. Thus we are always on the lookout for suitable projects that are eye-catching, inexpensive, and yet pedagogically solid. *Ink Sandwiches, Electric Worms, and 37 Other Experiments for Saturday Science* by Neil Downie has many good ideas.

Most of the projects Downie presents were developed over years of involvement with a Saturday morning children's club in his hometown of



Guilford, England. The projects are pitched at a level such that a physicist can reproduce them in a few hours' work at home with commonly available materials. Alternately, with some supervision, a student could also build the projects for a science fair or undergraduate course. The broad topics Downie covers are mechanics (linear, rotational, vibrational, and chaotic), fluids, sound, electromagnetism, electrochemistry, and electronics. Each chapter of the book consists of an introduction, building instructions, explanation, and a more detailed science and math section. The science will appeal to a broad age range. Fairly young audiences (elementary and middle school students) will like the demonstrations; with the addition of numerical analysis, they are also appropriate for grades 11 and 12 and for first-year undergraduates. Occasionally, the science and math section provides a note of uncertainty as to exactly why we see what we see—something I quite like.

A couple of simple examples in the book are worth mentioning. One is the generation and measurement of standing waves in a coffee cup. The vi-



brations are produced by a small electric motor with an eccentric weight on the axle, and a vane and photodiode measure the frequency. The demonstration contains a lot of physics, which only detailed measurements can reveal.

Another example demonstration involves balancing balls in a vertical air stream. In that experiment, Downie describes in detail a variation I had not seen before: balancing a column of several balls of increasing size. I'm not sure, though, that I agree with the stability analysis presented. The author says that a Ping-Pong ball that moves off axis rotates and is brought back by the Magnus force. My experience with somewhat heavier squash balls is that they refuse to rotate, even when suspended in an almost horizontal air stream. Surely the stability of the balls lies in the acceleration of the air, and the subsequent drop in pressure, as the air tries to get around each ball. This said, I am puzzled why squash balls will not rotate even in an axially asymmetric flow. Such is the nature of many of these "simple" effects, especially in fluids, that defy straightforward analysis.

There is a "Hints and Tips" section

at the back of the book that covers information about suppliers, data loggers, and the use of spreadsheet programs. If I could make a suggestion for the second edition, it would be to vastly expand this section. For example, coverage on data loggers gets a mere two lines. A multichannel analog-to-digital converter for a personal computer now costs less than \$100, and many sensors are also available for a few dollars each. Such obtainable electronics equipment, coupled with the ubiquity of PCs and spreadsheet programs, makes computer data acquisition and graphical analysis accessible to even the most strained high-school science budgets. A few pages of tutorial on how to set up data acquisition and graphical analysis for experiments would be very valuable.

Knowing something of the often exhausting business of science outreach and how long it takes to produce a five-minute demonstration, I recognize the huge effort that must have gone into this book. Downie is a particle physicist turned consultant and the author of a recent textbook on industrial gases; so everything that went into *Ink Sandwiches*—the development, presentations, and writing—must have been done during his leisure time. The book is a job well

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done, and I recommend it for anyone trying to get physics across to non-specialist audiences.

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Ultra-High Energy Particle Astrophysics

Shigeru Yoshida

Nova Science, Hauppauge, NY,

2003. \$89.00 (163 pp.).

ISBN 1-59033-593-7

Cosmic rays with energies greater than 10^{18} eV are the highest-energy particles in the known universe; where and how they are accelerated to such extraordinary energies is one of the most pressing problems in astrophysics. Although the current observational status looks like a bit of a mess, the study of ultrahigh-energy particles is coming of age, and astrophysicists have seen a constant improvement in the quality of experimental data. The Pierre Auger Observatory in Argentina's Pampa Amarilla has started to dramatically increase the number of recorded cosmic rays, and it promises to settle decisively some important observational issues. One example is the ongoing controversy concerning cosmic rays observed to have energies above a theoretical limit—the so-called GKZ cutoff—predicted by Kenneth Greisen, Vadim Kuzmin, and Georgi Zatsepin.

I was therefore rather excited to see a new textbook on cosmic-ray physics on the market. And the timing for *Ultra-High Energy Particle Astrophysics* by Shigeru Yoshida could hardly be better. However, the bar is high. A variety of books on astroparticle physics, even at the undergraduate level, now include well-written chapters on cosmic-ray physics. Simply being the newest book does not justify publication.

Yoshida has a long and distinguished track record in cosmic-ray research. He has worked on the Akeno Giant Air Shower Array (AGASA) cosmic-ray experiment in Japan and the High Resolution Fly's Eye (HiRes) Experiment in Utah; both have contributed significantly—and still do contribute—to the advance of ultrahigh-energy cosmic-ray physics. Yoshida's knowledge of the field shows, and he manages to squeeze a large number of relevant topics into a small volume of little more than 150 pages. In the first part of the book, he

describes cosmic-ray acceleration and propagation in an expanding universe. After that rather theoretical section, he summarizes the observational status and some experimental aspects of the field. The last chapters offer several interesting special topics—for example, the possible connection between ultrahigh-energy cosmic rays and gamma-ray bursts or neutrino physics.

Those last chapters have the most to offer. They contain the outlines of a number of interesting calculations that one cannot easily find elsewhere in such a compact form. Readers with a healthy mathematical constitution will find a lot to enjoy.

Unfortunately, the book is, for the most part, disappointing. In the theoretical section, Yoshida tries to

accomplish too much in too few pages. He describes his book as an "introductory textbook rather than a review for experts," but large stretches of the text amount to little more than collections of formulas. In a section billed as a brief introduction to general relativity and cosmology, Yoshida merely confronts the reader with a lot of math; there's almost no physics insight. His use of four-vector notation is often sloppy, and he takes it for granted that his nonexpert audience knows the comma derivative.

The chapters on experimental methods and observations suffer from a similar overabundance of formulas and dearth of explanation. Additionally, in my opinion, too much room is given to statistically unsound experimental results. That said, I find it laudable that Yoshida puts such a strong emphasis on observation.

Potential readers should be warned that the book is largely unedited and contains numerous errors, misleading expressions, and misspelled names of major scientists in the field. It appears that very little or no proofreading has gone into the book; that lack of care will, unfortunately, challenge the patience of even the most enthusiastic reader. One wonders how much more than the already steep price for this small volume one has to pay before Nova Science Publishers runs at least a spell check. The publisher also has to be blamed for the poor quality of many figures. Particularly bad are the black and white reprints of color plots, such as the figure-1.2 sky map of AGASA cosmic-ray arrival directions. Axis labels are often hard to read or, as in figure 5.13, misleading.

In summary, *Ultra-High Energy Particle Astrophysics* can serve as a useful collection of relevant formulas for scientists in the field. It is not a good book for nonexperts to read first, and it's certainly not an introductory textbook. Students are better off reading older books like Thomas Gaisser's *Cosmic Rays and Particle Physics* (Cambridge U. Press, 1990), supplemented with some recent journal papers and reviews, or opting for the carefully crafted and well-written *High Energy Cosmic Rays* by Todor Stanev, published this year by Springer.

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Introduction to Nanotechnology

Charles P. Poole Jr and

Frank J. Owens

Wiley, Hoboken, NJ, 2003. \$79.95

(388 pp.). ISBN 0-471-07935-9

Rarely has a scientific field created so much enthusiasm and expectation as has nanotechnology. Much of the hype is certainly the stuff of science fiction, but the exuberance, irrational or not, has quickly spread from the laboratory to Madison Avenue, Wall Street, and Washington, DC.

Nanotechnology is not a new field but rather a confluence of many fields—physics, chemical and electrical engineering, mechanics, materials science, chemistry, and biology—coming together at the nanometer scale. Much hope exists for vast improvements in each of these areas through developments in such fields as nanoelectronics, information technology, nanomachines, molecular electronics, nanotubes, microelectromechanical systems (MEMS), and microfluidity. The real excitement for nanotechnology, however, is driven by the integration of nanodevices and sensors into biological systems for diagnostics, drug delivery, and homeland security. Nanotechnology has thus evolved into a particularly interdisciplinary science.

In *Introduction to Nanotechnology*, Charles Poole Jr and Frank Owens set out to provide the background for specialists working in one area of nanotechnology to understand and contribute to advances made in other areas. This is a formidable challenge.

